

CHAPTER V APPLIED TROPICAL CYCLONE RESEARCH SUMMARY

1. JTWC RESEARCH

Part of the mission of the Joint Typhoon Warning Center is to conduct applied tropical cyclone research as time and resources permit. The purpose of this research is to improve the timeliness and accuracy of operational forecasts. During 1979, there was continued effort to convert and update operational programs and to streamline operational procedures for compatibility with the Naval Environmental Display Station. The following abstracts summarize the year's applied research projects which were completed or are still in progress.

ESTABLISHMENT OF THE JTWC TROPICAL CYCLONE DATA BASE

(Curry, W. T. and Matsumoto, C. R.,
NAVOCEANCOMCEN/JTWC)

A data base of 6-hour best track positions (intensities, direction and speed of movement) and 24-, 48-, and 72-hour objective technique and official JTWC forecasts for each tropical cyclone in the western North Pacific, Arabian Sea and Bay of Bengal from 1966 through 1978 has been established on FLENUMOCEANCEN computer mass storage systems. Tropical cyclone fix data (position, intensities, platform, etc.) for each tropical cyclone from 1966 through 1977 remain to be added. This climatological data base will be maintained on disk and tape files at FLENUMOCEANCEN Monterey, California and updated annually.

NEDS/COMPUTER APPLICATIONS

(Staff, NAVOCEANCOMCEN/JTWC)

JTWC's objective techniques have been converted by contractors to execute on FLENUMOCEANCEN computers. A NEDS graphic capability is being developed to depict forecast tracks from objective techniques. Evaluation and monitoring of program conversion will continue in 1980.

TROPICAL CYCLONE MINIMUM SEA-LEVEL PRESSURE - MAXIMUM SUSTAINED WIND RELATIONSHIP

(Lubeck, O. M. and Shewchuk, J. D.,
NAVOCEANCOMCEN/JTWC)

The pressure-wind relationship developed by Atkinson and Holliday (1977), Tropical Cyclone Minimum Sea Level Pressure - Maximum Sustained Wind Relationship for Western North Pacific, is a primary tool used to determine tropical cyclone intensities for JTWC operations. This relationship was re-evaluated and tested with an independent data set. The study produced no significant differences or changes. Therefore, the current Atkinson and Holliday relationship will continue to be used at JTWC. Other regression equations using case-dependent latitude and environmental pressure (versus 1010 mb) as predictors were also tested. These predictors did not improve the maximum sustained wind-minimum sea-level pressure relationship.

OBJECTIVE TROPICAL CYCLONE INITIAL POSITIONING WITH A WEIGHTED LEAST SQUARES ALGORITHM

(Lubeck, O. M. and Shewchuk, J. D.,
NAVOCEANCOMCEN/JTWC)

Recent studies indicate tropical cyclone forecast errors through 72 hours can be reduced by more accurate initial warning positions. This study developed an objective and standardized method of determining initial position based on all available fix information. A least squares algorithm was used on available fix data with a weighting scheme which is inversely proportional to the stated fix accuracies. The results of this objective method showed no significant improvement over the current subjective method. Therefore, this method was not incorporated into operational procedures. This method, however, produces an improved tropical cyclone "best track" and was incorporated into JTWC's post-analysis procedures.

EQUIVALENT POTENTIAL TEMPERATURE/MINIMUM SEA-LEVEL PRESSURE RELATIONSHIPS FOR FORECASTING TROPICAL CYCLONE INTENSIFICATION

(Dunnavan, G. M., NAVOCEANCOMCEN/JTWC)

The relationship between equivalent potential temperature at 700 mb in the center of developing tropical cyclones and associated intensity changes was explored by Sikora (ATR 1975), Milner (ATR 1976), and Hassebrock (ATR 1977). The Sikora and Milner studies produced conflicting results, but the Hassebrock study showed some skill in forecasting explosive and rapid deepening when 1977 and 1978 tropical cyclones were evaluated. Evaluation of 1979 tropical cyclones again showed that the Hassebrock technique has some skill. Unfortunately, dewpoint data from aircraft reconnaissance missions from earlier years are not readily available at JTWC, so it has been difficult to increase the data base. The Hassebrock study will be applied to 1980 tropical cyclones and any cyclones prior to 1976 for which data are available. The data base may then be large enough to draw some definite conclusions.

A related study of equivalent potential temperature was also started. A comparison was made of past 12- and 24-hour changes in equivalent potential temperature in the eye of a tropical cyclone with the subsequent 12- and 24-hour changes in 700 mb height. These correlations proved inconclusive, again due to the small initial data base. An attempt will be made to obtain more data for this study also.

BASIC STREAMLINE ANALYSIS AND TROPICAL CYCLONE FORECASTING TECHNIQUE GUIDE

(Guay, G. A., NAVOCEANCOMCEN/JTWC)

A case study, based on an active tropical cyclone period, is being developed. The study will be worked into a training guide for new forecasters and will include basic streamline analysis procedures as well as tropical cyclone forecasting techniques. The case study will also be integrated into STORMEX training (training scenario for DET 4 HQ AWS, 54 WRS, DET 1 LWW, JTWC, and AJTWC personnel).

IMPROVEMENT AND EXTENSION OF THE JTWC CLIMATOLOGY

(Shewchuk, J. D., NAVOCEANCOMCEN/JTWC)

Climatology is an important objective forecast aid for JTWC. A new climatology was developed for the western North Pacific which provides position and intensity forecast information for 24-, 48- and 72-hour intervals. Pertinent statistical information is produced by month for each latitude/longitude of available historical data, which includes 1945 to 1973.

Similar climatological information is being developed for the North and South Indian Oceans and the western South Pacific. The periods of available historical data are 1900-1970, 1900-1969 and 1900-1971, respectively.

2. NEPRF RESEARCH

TROPICAL CYCLONE RESEARCH AT OR UNDER CONTRACT TO THE NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY (NEPRF), MONTEREY, CALIFORNIA

TROPICAL CYCLONE MODELING

(Hodur, R.M., NEPRF and Madala, R., NRL)

A one-way interactive Tropical Cyclone Model (TCM) is being evaluated operationally. This model differs from the original channeled TCM, that has been used for the past three years, in two ways. First, hemispheric forecast data are used on the boundaries as opposed to the channel boundaries used in the original TCM. Second, a new bogus is used to represent the storm based on the observed maximum wind. This latter change has cut the average initial position error by 59% to 15 nm. The one-way interactive TCM average forecast errors at 48, 60 and 72 hr are 8%, 14% and 21% less than the channel model, respectively, for Pacific cyclones through August 1979. Both TCMs have about the same average forecast errors at 12, 24 and 36 hr.

A more sophisticated TCM is being developed jointly by NEPRF and NRL and is expected to become operational in 1981. This TCM includes the effects of surface friction, cumulus clouds and latent and sensible heat transfer from the ocean. Preliminary tests indicate that these improvements may reduce forecast track errors by 15% to 20% when compared to the one-way interactive TCM.

TROPICAL CYCLONE WIND DISTRIBUTION

(Tsui, T., Brody, L.R., and Brand, S., NEPRF)

The wind distribution around tropical cyclones for the warnings issued by the JTWC from 1966 through 1977 have been compiled and edited into a unique data set. An analysis of the wind radii shows the asymmetrical nature of the radii of 30 kt and 50 kt winds around tropical cyclones as a function of the characteristics of the storm. A statistical forecast model to predict the asymmetric wind distribution has been developed.

TROPICAL CYCLONE STRIKE PROBABILITIES

(Brand, S., NEPRF and Jarrell, J.D., Science Applications Inc.)

Tropical cyclone strike probability is a method for determining probabilities up through 72 hours that a tropical cyclone will come within specified distances around geographic points of interest to the user. This program can be used as an aid for operational decisions associated with tropical cyclone evasion, evacuation and base preparedness. Strike probability output is presently being evaluated by a number of Navy and Air Force meteorologists and operational customers in WESTPAC. Other applications of strike probability that are presently being developed include geographic depictions, wind probabilities and strike probabilities for EASTPAC.

A STATISTICALLY DERIVED PREDICTION PROCEDURE FOR TROPICAL CYCLONE GENESIS

(Perrone, T., Lowe, P., Rabe, K., and Brand, S., NEPRF)

A statistical experiment using stepwise discriminant analysis was conducted to determine algorithms to be applied to daily, operationally-available meteorological analyses. Parameters identified as potential predictors of tropical cyclone formation were statistically examined to determine their tropical cyclone genesis prediction capability and were found to possess substantial promise to predict tropical storm formation 24, 48 and 72 hours prior to occurrence.

EXTREME SEA STATES WITHIN A TYPHOON

(Rabe, K., and Brand, S., NEPRF)

Extremely high sea states are known to occur to the right of the direction of movement in typhoons. A well-documented case of such extreme sea heights in the western North Pacific was examined and compared with results from a numerical spectral ocean wave model. The wind and sea state field of the numerical model compared favorably with the observed data. An examination was also made to determine how extreme sea states relate to tropical cyclone intensity, forward speed of movement, and circulation size or wind distribution. The results indicated that all three are important with the intensity being the primary factor, speed of movement being of secondary importance and circulation size or wind distribution being the least important factor.

TROPICAL CYCLONE ORIGIN, MOVEMENT AND INTENSITY CHARACTERISTICS BASED ON DATA COMPOSITING TECHNIQUES

(Gray, W.M., Colorado State University)

Observational studies using large amounts of composited rawinsonde, satellite and aircraft flight data have been performed to analyze global aspects of tropical cyclone occurrences. The data were used to study the physical processes of tropical cyclone genesis, tropical cyclone intensity changes, environmental factors influencing tropical cyclone turning motion 24-36 hours before the turn takes place, tropical cyclone intensity determination from upper-tropospheric reconnaissance, and the diurnal variations of vertical motion in tropical weather systems.

IMPROVED UPPER-LEVEL TROPICAL CYCLONE STEERING TECHNIQUES

(Hamilton, H., Systems and Applied Sciences Corporation)

Current automated objective steering forecast techniques incorporating HATRACK and MOHATT algorithms are operationally termed CYCLOPS and may be run in analysis or prognosis modes at seven different atmospheric levels including 1000 mb, 850 mb, 700 mb, 500 mb, 400 mb, 300 mb and 200 mb. Since tropical cyclones vary greatly in areal and vertical extent and may be representatively steered at varying atmospheric levels dependent on state of development/intensity, continuing research is ongoing which will attempt to identify, given certain tropical cyclone input parameters, a "best" steering level or a "weighted scheme" that takes into account several steering levels.

AIRBORNE EXPENDABLE BATHYTHERMOGRAPH OBSERVATIONS IMMEDIATELY BEFORE AND AFTER PASSAGE OF TYPHOON PHYLLIS (AUG 75)

(Schramm, W.G., NEPRF and NAVPGSCOL)

Ocean thermal response to an intense typhoon was analyzed on the basis of data collected during the passage of Typhoon Phyllis (Aug 75) in the Philippine Sea. A unique data set was collected using calibrated Airborne Expendable Bathythermographs dropped from a Navy P-3 aircraft. There were three flights: the first, 14 hours before storm passage, the second 10 hours after passage, and the third two days later. The results indicate a dramatic upward movement of isotherms, relative to the sea surface, in a narrow band under the storm path, with a reversal toward pre-typhoon conditions within three days.

MESOSCALE EFFECTS OF TOPOGRAPHY ON TROPICAL CYCLONE ASSOCIATED SURFACE WINDS

(Brand, S. and Chambers, R., NEPRF, Woo, H., Cermak, J., and Lou, I., Colorado State University, and Danard, M., University of Waterloo)

An analysis was made of the influence of topography on tropical cyclone associated strong surface wind conditions for Subic Bay, Republic of the Philippines by means of an environmental wind tunnel. Surface flow patterns were deduced by smoke and surface oil films, while isotach and gust values were obtained by hot wire anemometers. The laboratory results show the significant effects of the mountainous regions surrounding the Subic Bay harbor complex and indicate preferred sheltered locations. The results were compared with synoptic observations and a high resolution (0.19 nm) diagnostic, one-level, primitive equation model. Where direct comparison could be made, all techniques appeared to show qualitative agreement.

TYPHOON HAVEN STUDIES

(Stevenson, G.A. and Brand, S., NEPRF)

The Typhoon Havens Research Program, the results of which have been summarized in NEPRF Technical Paper 5-76, has been resumed. COMSEVENTHFLT has identified an additional 12 ports and harbors for evaluation as typhoon havens. Work has commenced on Palau, Saipan and Tinian.